user story

Optimisation of combustion chamber geometry for improved exhaust emissions

In order to reduce exhaust gas emissions, multiple computations must be completed to carry out engine design optimisations.

In this application, our customer was keen to deliver equivalent engine performance in a medium duty diesel engine whilst reducing corresponding exhaust gas emissions by redesigning the piston bowl geometry.

THE CHALLENGE

Examine combustion chamber effects on emissions in a diesel engine

THE SOLUTION

Coupling a 3D CFD code with srm suite software to simulate diesel fuelled engine combustion with detailed chemical kinetics.

THE RESULTS

•3D CFD was solved with detailed chemistry taking almost one month

•3D CFD coupled with srm suite (including detailed chemistry) in eight hours

•In both cases, the model proved reliable compared to experiments

•Piston bowl design proved influential upon exhaust gas emissions

THE CHALLENGE

Diesel combustion occurs with high amounts of fuel stratification, conventionally in order to account for these inhomogeneities, 3D CFD software codes are adopted. In this application, to solve for combustion and emissions, one month of computational time was required on a single processor.

These timescales are not appropriate for engine design optimisation hence the combustion and emissions models are usually simplified with loss of model robustness and predictive capability.

Hence, the features of a 3D CFD simulation with detailed chemistry must be obtained over shorter timescales.

THE SOLUTION

The temperature–equivalence ratio statistics obtained 3D CFD were mapped into the srm suite code to study the impact of combustion chamber design (open bowl, vertical side wall bowl and re-entry bowl) combustion and emissions.

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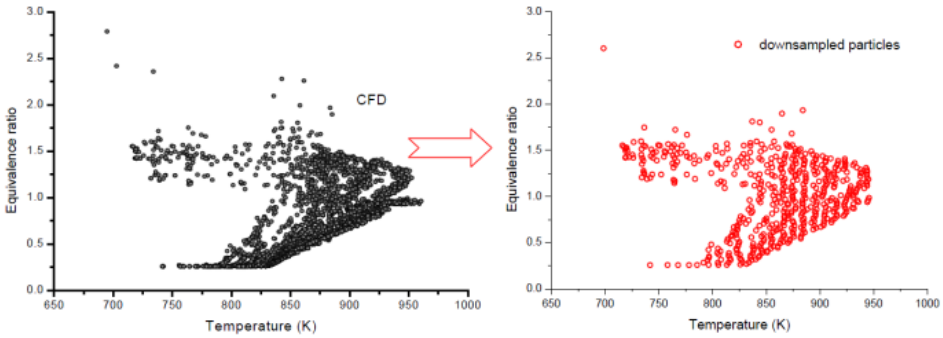
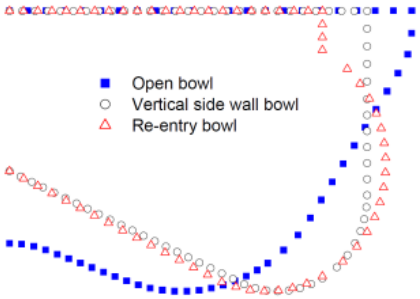
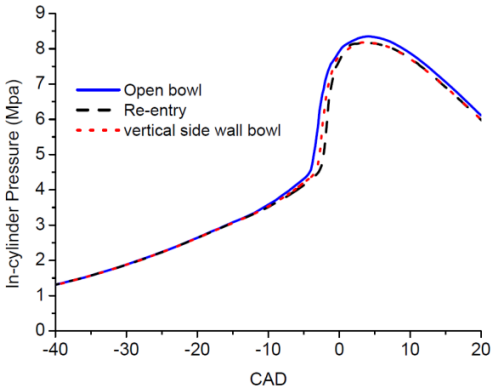
The result of the 3D CFD computation at the transition point and the initial ensemble data selected as the initial state of the srm suite.



(a) CFD (b) Downsampling





Adopted piston geometries and their impact on the in-cylinder pressure. Here the different geometries made only a subtle difference to the in-cylinder pressure profiles.

APPLICATION AREAS

- Conventional diesel
- HCCI
- PCCI

PRODUCTS USED

- srm suite

THE RESULTS

• Equivalent 3D CFD model performance in reduced timescales

Firstly, the results obtained from the 3D CFD model and those obtained from the 3D CFD/srm suite model were almost identical, however the computational times were around one month and eight hours respectively. Both computations agreed well with those observed experimentally.

•Insight into combustion chamber design

Three alternative piston geometries were simulated, in this case making little impact on the pressure profiles. However these subtle changes in the in-cylinder flow field resulted in differing exhaust emissions. By considering these computations, subtle improvements to the piston geometry were obtained.

	NO_x [ppm]	CO [ppm]	uHC [ppm]
Open bowl	66	2720	376
Re-entry bowl	6	2480	580
Vertical side wall bowl	35	2450	482

Corresponding emissions for the three piston geometries

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